
Holistic Framework for COVID-19 Pandemic as Systemic Risk*

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Abstract:

Purpose: The aim of this study is to provide knowledge to manage the holistic nature of the COVID-19 pandemic.

Design/Methodology/ Approach: The theoretical framework of COVID-19 research forms a matrix of multidiscipline scientists from medics, epidemiologists, sociologists, economists, and full life cycle performance. This ground level creates systemic risk in form of White Swan. The next layer are costs of pandemic private, public, club, merit costs. This is Black Swan model of COVID-19 pandemic as systemic risk. In the top layer we see Green Swan and pure uncertainty. Each of the elements of a Systemic Matrix is different in every country.

Findings: In our opinion, COVID-19 pandemic should be described in the language of systemic risk. There is uncertainty if nature of COVID-19 is endogenous or exogenous? The matrix of COVID-19 understanding is crowned by well-being and the perception of the risk of COVID-19 among the various participants in the economy.

Practical Implications: Knowing that COVID-19 pandemic is Green Swan we may use Resolution Funds to support Public-Private network for testing and vaccines.

Originality/value: Our theoretical language opens cross disciplinary communication on COVID-19 pandemic. Now, we can discuss on distribution of cost of COVID-19 pandemic between participants of this multilevel systemic process. This is also cost of blocked transgenerational transfers. Some people lost life, some lost social capital because of the loss of grandparents.

Keywords : Pandemic, systemic risk, systemic matrix, green, white and black swans.

JEL classification: E61, G01, H12, H115, J2, J17, Z13.

Paper Type: Research study.

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1. Introduction

Traditional systemic risk management relies on scenario-based evaluations and analyses of policymaker interference. This popular approach is based on expert opinion and is relatively easy to implement. On the other hand, modern systemic risk management is based on gigantic databases collected on IT platforms. In this case, the opinions of experts merely supplement the overall management of systemic risk, which in fact uses information from both structured quantitative sources and unstructured semantic sources such as social media. In this way, in managing the systemic risk of a pandemic, we skip smoothly from an intuitive search for an analogy to the existing situation over to risk assessment based on qualitative expertise supported by econometric models.

Currently, the systemic risk management of a pandemic is based on basic risk indicators (such as the number of people who severe disease compared with the number of people who have recovered) along with some more detailed indications (such as the number of people discharged from and the number of people admitted to such and such a hospital). Then, we are still left with an analysis of unstructured data related to citizens' emotions. In the long run, it will be possible to monitor the pandemic via an integrated, holistic system of systemic risk management.

There are two approaches to managing systemic risk. One is passive and assumes that each market failure or anomaly is individual and unique. However, in practice they are well described by the statistics of normal distribution and the value at risk method. In the second approach, the context of applying universal methods of risk management means that they have to be applied while taking into account the possibility that events may occur that are highly unlikely yet cause huge losses. These types of events are called black swans. Epidemiologists were prepared for the fact that sooner or later a 'pandemic of the century' would emerge (Gates 2020). In the language of risk management, 'systemic' means that the appearance of a 'green swan' was expected. Table 1 compares the concepts of white, black and green swans.

Table 1. *A typology of swans: similarities and differences*

Dimension	White Swans	Black Swans	Green Swans
Predictability through	Gaussian, normal distribution	Tail risks, perhaps non-Gaussian. Ex-post rational explanation, after occurrence	Highly likely or certain occurrence but uncertain timing of occurrence and materialisation. Too complex to fully understand.
Main explanation by	Statisticians, economists	Economists, financial analysts and risk managers with some disagreement	Scientists, disagreement with many economists and financial analysis

Impacts	Low or moderate	Massive and direct mostly material. Possible correction of damages after event	Massive and direct impact mostly to human lives (or even civilisational). Irreversibility of damages in most cases.
Policy recommendations	Risk models are fine (can be marginally improved)	Reconceptualise approach to risk. Learn from event to design anti-fragile strategies.	Given severity of effects, even without full understanding, need for immediate action and coordination under radical uncertainty

Source: Silva 2020 p. 6.

Each form of systemic thinking about far-reaching and interrelated changes is similar to others on a continuum ranging from full knowledge to full uncertainty and ignorance. Each concept of risk is illustrated respectively by: the white swan for systematic risk and seasonal flu, the black swan for endogenous systemic risk and global financial crisis, and the green swan for exogenous or endogenous systemic risk and the COVID-19 pandemic.

The hidden elements of the white, black and green swan concept are its two dimensions. The first concerns the ability to survive: prevention, accepting losses, sharing them among the stakeholders, and adapting to the new normality. The second dimension involves the phases of systemic risk management: defining the context of the shock that threatens the continuation of the system, the multiplier of disruptions, their critical points, recognising the systemic nature of the disturbances, introducing preventative measures to avoid moral hazard, risk reduction by dividing it up, risk trading, and the conscious aggravation of risk so that it might eventually become a political risk. Table 2 uses the white, black and green swan division to describe strategies to combat the COVID-19 pandemic in selected countries.

Table 2. *Traditional and modern methods of managing the systemic risk of the COVID-19 pandemic in selected countries*

The essence of the pandemic	White Swan	Black Swan (we'll wait and see)	Green Swan (we'll get ahead of the situation)
Nature	Belarus (God's indulgence)	Sweden, Mexico (herd immunity: "it's not worse than the flu")	Poland (incidence rate test scale derivative)
Bioengineering	Hong Kong, Taiwan, South Korea, Japan (masks and tests) China (isolation)	United States	Poland (incidence rate test scale derivative) Germany (redundant intensive care potential)

Source: Solarz, Waliszewski 2020.

A COVID-19 risk perception study in 10 countries (United Kingdom, United States, Australia, Germany, Spain, Italy, Sweden, Mexico, Japan, South Korea) revealed that it was perceived as high between January and April 2020, with 4.78–5.45 on a 7 point scale. It was more socio-economic and psychological than medical. Trust capital, pro-social orientation and personal experience with epidemics were of particular importance. Those with their own experiences of living in times of pestilence as well as carers were more emotionally affected. For example, in South Korea and Spain, trust in state authorities lowered the subjective sense of risk (Dryhurst *et al.*, 2020).

Recovery and adaptation in the aftermath of disruptions is a requirement for interconnected 21st Century economic, industrial, social, and health-based systems, and resilience is an increasingly crucial part of strategies to avoid systemic collapse. This strategy includes:

1. Design systems, including infrastructure, supply chains, economic, financial and public health systems, to be resilient, i.e. recoverable and adaptable.
2. Develop methods for quantifying resilience so that trade-offs between a system's efficiency and resilience can be made explicit and guide investments.
3. Control system complexity to minimise cascading failures resulting from unexpected disruption by decoupling unnecessary connections across infrastructure and make necessary connections controllable and visible.
4. Manage system topology by designing appropriate connection and communications across interconnected infrastructure.
5. Add resources and redundancies in system-crucial components to ensure functionality.
6. Develop real-time decision support tools integrating data and automating selection of management alternatives based on explicit policy trade-off in real time (Hynes, Linkov, and Trump, 2020).

The proposed map of the risk accompanying the COVID-19 pandemic enables the methods of combating it to be individualised. Instead of life or death, economic activity or contagion strategies, a win-win type of strategy is proposed – that is, to protect everyone's life without exception while people remain professionally active during the pandemic. For analyses along the lines of something-for-something, the discounted value of further human life is used. At the same time, in order to make a valuation, the value of the potential consumption of the deceased is calculated. To simplify the calculation, it is assumed that a year of life is worth 6 years of its annual consumption (Hall, Jones, and Klenow 2020). Then, the effectiveness of the subsidy policy for the survival of enterprises or the cost of the financial policy aimed at restoring effective demand is examined (Boissay, Rees, and Rungcharoenkitkul 2020).

Individually, people value health more than wealth. The extent to which such preferences translate into a change in health and financial habits varies widely. Mortality and interpretation statistics are a key element (Heap, Koop, Matakos, Unan, and Weber 2020). In the media, mortality is shown on logarithmic scales. Public communication takes place on linear scales. They are correctly interpreted by the majority of citizens. The linear scales show the development of the pandemic uncontrolled, the logarithmic scale flattens the illness curve, and so the linear scale evokes concern in the constituents (Romano, Sotis, Dominioni, and Guidi 2020).

We can limit the role of such rhetoric by demanding more precise language that quantifies risk on an absolute scale, effectively assigning “micromort” as a unit of risk defined as one-in-a-million chance of death. While the quantification of risk and its uncertainties is scientific, perception of acceptable risk is subject to personal judgment that will vary with life experience and factors such as whether the risk is voluntary or not (Roberts, 2013).

If individuals come to believe that the virus is more infectious, then they upwardly revise their assessment of the probability that they will get the virus even if they socially distance. But if individuals come to believe that they are likely to get the virus no matter what they do, then they may decide to ignore social distancing measures: in other words, we encounter a rational “fatalism effect” (Akesson, Ashworth-Hayes, Hanh, Mecalfe, and Rasool 2020).

Perceived personal health risks associated with Covid-19 fall sharply with age. Younger people have far higher assessments of Covid 19 health risks, for themselves as well as for others, than older people (Bordalo, Coffman, Gennnioli, and Shleifer 2020). The provision of timely, regularly updated and comparable granular data on excess mortality by national and international statistical agencies should be high on the agenda (Aron and Muellbauer 2020).

The holistic concept of the COVID-19 pandemic must simultaneously take into account its three dimensions. The first is a reduction in mortality among those infected with the coronavirus. The second is to ensure conditions for the continuation of life in circumstances of health and financial security. The third is building social capital and well-being in the circumstances of a new normality (Lustig, Stone, and Tommasi, 2020).

The basic problem associated with the COVID-19 pandemic is putting it in the right cognitive framework, starting with its time and space. Table 3 presents the cognitive framework of the COVID-19 pandemic. Goods and services differ in terms of the degree to which their production and consumption requires physical interaction (Snower, 2020).

Table 3. *Cognitive framework of the COVID-19 pandemic*

Time\space	Closed space	Open space
Time-saving technologies	Epidemiological tests	Applications monitoring the epidemiological distance
Time-consuming technologies	Outbreaks of plague	Epidemiological coma (Lockdown)

Source: *Own study.*

Manufacturing and services are supported by remote work (saving time spent in direct contact) or face-to-face contacts. Production and services are provided in virtual (open) or closed space. The COVID-19 virus spreads particularly vigorously in confined spaces. Screening tests to determine who is infected are crucial in this environment.

The scale of losses caused by the COVID-19 pandemic put it on a par with the global financial crisis (GFC) in terms of systemic risk. The post-pandemic recession differs significantly from the GFC. Firstly, it is truly exogenous in nature and not due to economic imbalances brought to light. Secondly, it creates uncertainty rather than measurable risk. The source of risk is non-economic factors. Thirdly, it has a truly global reach. There is practically no country unaffected by the COVID-19 pandemic. A methodologically correct methodology for comparing the effectiveness and efficiency of fighting the COVID19 pandemic must take into account the economic goods in which its costs are calculated.

Analyses have thus far focused on the consequences of the COVID-19 pandemic for the public finance sector. The prospect of inventing an effective vaccine in circumstances of anti-vaccine protests is a reminder of the importance of public goods for health and financial security. In practice, for resident taxpayers there is a choice between intergenerational transfers or privatising the costs of a pandemic.

South Korea's success in the struggle against the COVID-19 pandemic shows that the supply of applications that track contact between people during the pandemic, i.e. coexisting goods (digitisation), are an ally of decision-makers looking for solutions beneficial to all stakeholders.

Therefore, a comprehensive analysis of the COVID-19 pandemic as a systemic risk requires that losses incurred in all types of public goods affecting all the stakeholders of this process be recognised as costs, with their differentiation in time and space. A pandemic can impact an economy in many ways: reductions in people's willingness to work, dictations in consumption patterns and lower consumption, added stress on the financial system and greater uncertainty leading to lower investment. These are respectively referred to as (labor) supply shocks, demand shocks, financial shocks and uncertainty shocks (Lin and Meissner, 2020).

A natural question is whether individual behaviour is the most desirable based on social criteria or the aggregation of the costs and benefits of each individual's behaviour for all people (Gersovitz and Hammer, 2003).

2. Literature Review

The uncertainty surrounding the World Health Organization's announcement of a pandemic has focused the attention of researchers on determining whether we are dealing with a known or a new coronavirus. Attempts have been made to establish the actual mortality and where it has characteristics of excess mortality. Who to protect first? Who should be allowed to work directly at their place of work? It was quickly established that no pharmaceuticals are available to limit the rate of coronavirus spread, so all that remained were changes in social distancing. The pandemic was recognised as being spread from one person to another by airborne droplets.

An lockdown froze the labour market and severed service and manufacturing links in the global economy. In practice, the weaknesses of having transformed China into a world factory were acknowledged. The global financial crisis began to be compared with the shock of the COVID-19 pandemic (Breitenfellner and Ramskogler, 2020). Publications questioned the legitimacy of comparing the COVID-19 pandemic with the global financial crisis (Danielsson, Macrae, Vayanos, and Zigrand, 2020). It is pointed out that this time the banks are part of the solution to the problem and are not creating a spontaneous shock for the economy and society (Strauss-Kahan 2020). Currently, review articles have emerged comparing different types of pandemics (68 Flu, SARS 2003, H1N1, MERS 2012, Ebola 2014, Zika 2016) and their socio-economic consequences (Ma, Rogers, and Zhou, 2020].

3. The Problem Statement, Objectives and Research Hypotheses

The scale of losses caused by the COVID-19 pandemic is comparable to the losses caused by the global financial crisis of 2007-2009. Under these circumstances, our description of the COVID -19 pandemic refers to the achievements of research on systemic risk management.

The main hypothesis of the study is that the COVID -19 pandemic is a manifestation of exogenous or endogenous systemic risk (Green Swan). Following on from this, auxiliary hypotheses were formulated that delaying the recognition of the epidemic as a pandemic involves losses of approx. 2% of GDP for each week of delay.

Another supporting hypothesis states that how the losses caused by the COVID-19 pandemic are financed will determine the new epidemiological normality in the world.

4. Risk Accumulation – Transformation of Partial Risk into Systemic Risk

The COVID 19 pandemic risk matrix has two dimensions. The first concerns survivability. The second involves the successive phases of managing a pandemic as a systemic risk.

The COVID-19 pandemic is of major significance to the insurance sector when considering the contractual coverage of health risks and mortality. These impacts are multifaceted, and some positive effects counterbalance the drawbacks. While for well-managed insurers the pandemic is not a “black swan”, it is significant when coupled with changes in financial assets and interest rates. A situation where insurance can be purchased against *force majeure*, as we are currently experiencing, may be perceived as maturity on the part of those who manage systemic risk, in this case the COVID-19 pandemic. The far-reaching impact of COVID-19 requires constant vigilance from both regulators and insurers. In the post-pandemic phase, the emergency measures currently in place will have to be developed through a carefully designed exit strategy that, while maintaining sound risk management practices, will safeguard the

Life insurance retracted to levels (premiums collected relative to GDP) found 35 years ago in the United States and Japan, and 20-25 years in the United Kingdom, Germany, and Switzerland. Only new products, considering price discounts for a healthy lifestyle and assistance for people suffering from senile dementia, can reverse the situation (*Addressing ...*, 2020).

A chain of relationships can be laid out between the various aspects of the overall COVID-19 crisis. Epidemiological phenomena are of a primary nature. We can neither protect ourselves against the appearance of the virus nor effectively combat its spread. This led to a medical collapse and a humanitarian disaster on a whole new scale. This, in turn, translated into an unprecedented global economic crisis. The next significant link in this chain of events is the political consequences.

The real “new normal” following the pandemic will emerge when insurers offer a whole range of insurance products resulting from the coexistence of society and the economy with the risk of contracting the coronavirus. The question remains as to who will ultimately pay for the losses caused by COVID-19. The answer to this question largely determines whether it will be possible to prevent further humanitarian disaster and to stand together to cover the costs connected with the materialisation of systemic risk (Jenny, 2020).

Optimistic scenarios for the unfolding of events include inventing a vaccine for the coronavirus, minimizing the side effects of a COVID-19 vaccination, developing herd immunization against this pandemic, isolating infected individuals from the healthy population. Realists remind us that there is no cure for AIDS, SARS or

MERS, there are no vaccines for many epidemiological diseases, there is no certainty that such a thing as herd immunisation exists, there is no evidence of human solidarity (Beinhocker 2020).

5. Discussion and Limitations

The attempt to combine the achievements of epidemiologists and systemic risk management specialists is a pioneering endeavour. The search for functional equivalents of the concept of systemically important institutions ends in most cases with intensive care units and the number of ventilators offering artificial respiration for patients. The next step in this direction should be prevention and screening, whereby the key issue is to perform tests on a large scale. In this regard, the institutions of systemic importance should be laboratories authorised to verify other results.

An outcome of research on financial system risk is the recognition of panic as a factor of systemic importance. Not only emotions lie at its source, but nowadays software or supervisory regulations play a role too. The fact that individual behaviour is systemically important has been rediscovered by epidemiologists who are tasked with reducing systemic risk without vaccines and drugs.

More research is needed on the systemic importance of individuals' health and financial habits in terms of the spread of the COVID-19 pandemic. Technologies of person to person and B2B direct virtual contact have their place in the formation of herd behaviour. This line of research requires further development. A certain shortcoming of our research is the omission in the quality analysis of systemic risk management by local government units. Financial systems are highly centralised and the spatial dimension is sometimes overlooked in their analysis. In the event of the COVID-19 pandemic, the quality of management in a given local government unit is absolutely crucial when it comes to how far the epidemic spreads. The pandemic response needs to be a holistic one, combined with an improved data ecosystem between the public health system and the community.

During COVID-19 pandemic, a scapegoat was sought, as it was in the global financial crisis. Non-bank financial intermediaries (shadow banking) were held to account for the risk incurred by the financial system; for the pandemic risk in many countries, the private health service became the scapegoat, which contributed significantly to the soaring death rate among the residents of old people's homes.

The experience of the financial sector has shown that the stigmatized non-bank financial intermediaries have grown by 50% in the decade separating us from the global financial crisis. Therefore, one should talk about public-private partnership in the health care system, and not limit postulation to either a public or a private system. Mixed public and private health systems all too often lead to what is known

as public service cannibalism, with the best staff moving from public to private health. Intellectual property is patented more effectively in the private health sector. The moral hazard of a hybrid health system requires a clear definition of their domains, without considering one form better than the other.

The quality of the statistics poses a serious limitation to the analysis performed. Despite uniform standards from the World Health Organization, the coronavirus mortality statistics are unreliable and difficult to compare. It would seem to be in the interest of mankind to introduce a global service to determine the causes of deaths and indicate the systemic threat to humanity. The appointment by the G20 countries of the Financial Stability Council was just such a step towards establishing services responsible for monitoring systemic risk on a global scale. Our concept of the pandemic shall move to an interdisciplinary science, with an integrated approach of medical sciences and public health with medical research and development, financial science, diplomacy, biomedical science, big data, information technology, artificial intelligence, statistics, meteorology, biotechnology, ecology and social sciences – all combined to provide an integrated cycle of prevention, preparation, response and recovery.

6. Conclusions

COVID-19 is a manifestation of a green swan, a phenomenon that will materialise sooner or later and generate huge external costs for humanity. As soon as the green swan emerges, we ask ourselves if the price we are paying for rationalising healthcare might be too high. In this case, we are choosing literally between human survival and the habits of ostentatious consumption. The COVID-19 pandemic continues. Its development in the language of systemic risk management is presented in Table 4.

Table 4. Milestones in the unfolding of the COVID-19 pandemic

	Name	Key words
1.	Context	Decoupling of system and lifeworld
2.	Shock	COVID-19
3.	Multiplier	Tourism, mass events, closed facilities
4.	A turning point	High mortality of infected seniors a
5.	Acceptance	State of the pandemic
6.	Prevention	Epidemiological distance, protective masks
7.	Reduction	Immediate freezing of interpersonal contacts in the public sphere
8.	Transfer	Postponement, regulatory arbitration
9.	Increasing the scale of systemic risk	New normalcy

^aThe methodology of COVID-19 death statistics raises serious questions. Official figures are estimated at 25-30% of the actual statistics [Jinjarak i in., 2020]

Source: Own work.

Each time we encounter a systemic risk, we face the choice of either to rebuild the past reality, which will sooner or later rematerialise the systemic risk, or to seek a so-called new normality.

Our collective memory is not able to refresh the experience of one hundred years ago and the devastation caused by the “Spanish” flu. Such extreme experiences require the search for new analogies. Applying the achievements of research on financial system risk to analyse the COVID-19 pandemic opens up new ways of combating the external costs of the globalisation of the economy and the functioning of humanity. We learned 10 years ago that we need to look at how the system as a whole has performed under duress and whether and how it might be strengthened. Focussing on the resilience of one or another element without understanding its broader effect will yield a false picture.

Another lesson learned from the global financial crisis was that monetary and fiscal policies must be coordinated. This underscores the importance of coordinated economic and public health responses. While at present the goal of enforced measures is to slow down the development of the epidemic so that the number of patients that require intensive care is within the capacity of the healthcare system, at some point the quarantine period has to end. The estimated infection fatality rate is close to zero for children and younger adults, but rises exponentially with age, reaching about 0,3% for those aged between 50–59, 1% for 60–69, 4% for 70–79, and 24% for people aged 80 and above. The age-dependent contact matrices are matters (Levin, Cochran, and Walsh, 2020).

References:

- Addressing Obstacles to Life Insurance Demand. 2020. The Geneva Association, Geneva.
- Akesson, J., Ashworth-Hayes, S., Hahn, R., Metcalfe, R.D., Rasooly, I. 2020. Fatalism, beliefs, and Behaviors during the Covid-19 Pandemic. NBER, Working Paper 27245.
- Aron, J., Muellbauer, J. 2020. Measuring excess mortality: the case of England during the Covid -19 Pandemic. Institute for New Economic Thinking, Oxford Working Paper no 11.
- Beinhocker, E. 2020. Exiting and Learning from the Pandemic. Oxford Institute for New Economic Thinking.
- Boisay, F., Rees, D., Rungcharoenkitkul, P. 2020. Dealing with Covid-19: Understandings the policy choices. BIS Bulletin.
- Bordalo, P., Coffman, K.B., Gennaioli, N., Shleifer, A. 2020. Older people are less pessimistic about the health risks of Covid -19. NBER, Working Paper 27494.
- Breitenfellner, A., Ramskogler, P. 2020. How deep will it fall? Comparing the euro area recessions of 2020 and 2009. SUERF Policy Note. No 150.
- Danielsson, J., Macrae, R., Vayanos, D., Zigrand, J.P. 2020. The coronavirus crisis is no 2008. CEPR Policy.

- Dryhurst, S., Schneider, C.R., Kerr, J., Freeman, A.L., Reccia, G., Bles, A.M., Spiegelhalter, D., Linder, S. 2020. Risk Perceptions of COVID-19 Around the World. *Journal of Risk Research*, 5.
- Gersovitz, M., Hammer, J.S. 2003. Infectious Diseases, Public Policy, and the marriage of Economics and Epidemiology. *The World Bank Research Observer*, vol 18, no 2.
- Hall, R.E., Jones, C.I., Klenow, P.J. 2020. Trading off consumption and COVID-19 deaths. NBER, Working paper 2734.
- Heap, S.H., Koop, C., Matakos, K., Unnan, A., Weber, N. 2020. COVID-19 and people's health-wealth Preferences: Informative effects and policy implications. *Quantitative Political Economy*, Working Paper No 5.
- Holistic Framework for Systemic Risk in the Insurance Sector. 2019. *International Association of Insurance Supervisors*, 14.
- Hynes, W., Linkov, I., Trump, B. 2020. A Systemic Approach to Dealing with Covid-19 and Future Shocks. *OECD*.
- Jinjarak, Y., Ahmed, R., Nair-Desai, S., Xin, W., Aizenman, J. 2020. Accounting for Global COVID-19 Diffusion Patterns. NBER, Working Paper 27185.
- Joyf, S. 2020. Initial assessment of insurance coverage and gaps for tackling COVID-19 impacts. *OECD*, Paris.
- Levin, A.T., Cochran, K.B., Walsh, S.P. 2020. Assessing the age specificity of infection fatality rates for COVID-19: Meta-Analysis and Public Policy Implications. NBER, Working Paper 27597.
- Lin Z., Meissner, C.M. 2020. Health vs. wealth? Public health policies and the economy during COVID-19. NBER, Working Paper 27099.
- Lustig, N., Stone, S.Z., Tommasi, M. 2020. Covid-19 and social protection of poor and vulnerable groups in Latin America: a conceptual framework. *UNDP Policy Documents Series*, No 8.
- Ma, C., Rogers, J., Zhou, S. 2020. Modern pandemics: Recession and recovery. *BOFIT*, Discussion Paper no 16.
- Roberts, D. 2013. Quantifying Life Risks in Micromorts and Microlives. *Risk Frontiers*, Briefing Note no 263.
- Romano, A., Sotis, C., Dominioni, G., Guidi, S. 2020. The public do not understand logarithmic graphs used to portray COVID-19. *LSE blog*.
- Silva, L.A.P. 2020. Green Swan 2-Climate change and Covid-19: reflection on efficiency versus resilience. *Bank for International Settlements*.
- Snower, D. 2020. The Socio-Economics of Pandemics Policy. *IZA*, Policy Paper No 162.
- Solarz, J.K., Waliszewski, K. 2020. Całościowe zarządzanie ryzykiem systemowym. *Pandemia COVID-19*. Wydawnictwo naukowe Edu-Libri.
- Strauss-Kahn, M.O. 2020. Can we compare the CPVID-19 and 2008 crises? *SUERF*. Policy Note no 164.